**SVKM's**

**D. J. Sanghvi College of Engineering**

**Program: B.Tech in Chemical Engineering** **Academic Year: 2022** **Duration: 3 hours**

**Date: 07.01.2023**

**Time: 10:30 am to 01:30 pm**

**Subject: Heat Transfer Operation - I (Semester V)** **Marks: 75**

**Instructions: Candidates should read carefully the instructions printed on the question paper and on the cover page of the Answer Book, which is provided for their use.**

**(1)** This question paper contains two pages.

**(2) All Questions are Compulsory.**

(3) All questions carry equal marks.

**(4) Answer to each new question is to be started on a fresh page.**

**(5) Figures in the brackets on the right indicate full marks.**

**(6) Assume suitable data wherever required but justify it.**

**(7)** Draw the neat, labelled diagrams, wherever necessary.

| Question No. | | Max. Marks |
|---|---|---|
| Q1 (a) | A surface at 250 $^0$C is exposed to the surroundings at 110 $^0$C transfers heat to the surrounding by convection and radiation simultaneously. The convection coefficient is 75 W/m$^2$ $^0$C. If the same amount of heat is conducted to the surface through a solid of conductivity 10 W/m $^0$C, what is the temperature gradient at the surface in the solid? | [05] |
| Q1 (b) | Derive an expression for rate heat transfer by conduction through thin cylinder wall and composite cylinder wall. | [10] |
| | **OR** | |
| | i. Derive the formula to calculate **Critical radius of Insulation** for a circular pipe. | [05] |
| | ii. Prove that the heat loss per square meter of outside surface area of a hollow sphere heated from within is equal to $$q = \frac{2k(T1 - T2)}{(D2 - D1) * (\frac{D2}{D1})}$$ Where *T1* and *T2* are the temperatures and *D1* and *D2* are the diameters of the inner and outer surfaces respectively. | [05] |
| Q2 (a) | i. A steel ball 100 mm in diameter and initially at 900 $^0$C is placed in air at 30 $^0$C. Find the temperature of the ball after 30 seconds. h = 20 W/m$^2$ $^0$C, $k_{steel}$ = 40 W/m K, $\rho$ of steel = 7800 kg/m$^3$, Cp of steel = 460 J/kg $^0$C. | [06] |
| | ii. Write about advantages and disadvantages of dimensional analysis. | [04] |
| | **OR** | |
| | Derive the relation for Nusselt number in natural convection using Rayleigh' s method. | [10] |
| Q2 (b) | Write note on Grashoff Number and Prandtl Number. | [05] |

| | | |
|---|---|---|
| Q3 (a) | i. In a flat-bottom cylindrical copper vessel (250 mm ID) water is boiled at the rate of 50 kg/h at atmospheric pressure. What is the temperature at the bottom surface of the vessel?<br>Data: -<br>1. Properties of water at 373 K, $\rho_L$= 958 Kg/ $m^3$, Cp = 4220 J/kg K, $\mu$=282×$10^{-6}$ Pas, Pr=1.75<br>2. Properties of steam at 1 atm & 373 K, $\rho_v$= 0.598 Kg/ $m^3$, $\lambda$ = 2255 KJ/Kg, $\mu$=282×$10^{-6}$ Ns/$m^2$<br>3. Surface tension at the liquid-vapor interface, $\sigma$ =0.05881 N/m<br>4. n=1, Csl =0.013<br><br>ii. Differentiate between dropwise and film condensation.<br>**OR**<br>A vertical plate 350 mm high and 420 mm wide, at 40 $^0$C, is exposed to saturated steam at 1 atm. Calculate the following**:** -<br>1. The film thickness at the bottom of the plate.<br>2. The maximum velocity at the bottom of the plate.<br>3. The total heat flux to the plate.<br>Assume vapor density to be very small compared to liquid density.<br>5. The Properties of condensate at mean film temperature are: - $\rho_L$= 977.8 Kg/ $m^3$, k = 0.667 W/m K, $\mu$=0.4×$10^{-3}$ Pas, $\lambda$ = 2255 KJ/Kg. | [07]<br><br><br><br><br><br><br><br><br>[03]<br><br>[10] |
| Q3 (b) | Assuming the sun to be a black body emitting radiation with maximum intensity at a wavelength of 0.49 µm. Calculate The surface temperature of sun and the heat flux at surface. | [05] |
| Q4 (a) | Write four laws of radiation and explain shortly.<br>**OR**<br>A 5 cm n. b. pipe (I.D. = 52 mm, O. D. = 60 mm) has eight rectangular longitudinal fins welded to the outer surface. The fins are of 5 cm length and 1.6 mm thickness. The wall temperature of the pipe is 160 $^0$C. The finned tube loses heat to a flowing stream of air (Tair = 27 $^0$C) with a surface heat transfer coefficient of 115 W/$m^2$ $^0$C. The thermal conductivity of the fin material is 46 W/m K. Neglecting heat transfer from the edges of the fins (adiabatic fin tip), Calculate a) Fin efficiency b) The rate of heat transfer to the air per meter length of the finned pipe. | [08]<br><br>[08] |
| Q4 (b) | Derive formula to calculate Ui in a DPHE. | [07] |
| Q5 (a) | **Solve any two.**<br>i. Differentiate between DPHE and STHE<br>ii. Give design procedure for DPHE<br>iii. Write about baffles in STHE<br>iv. Explain Pitch arrangements for tube bundle in STHE | <br>[05]<br>[05]<br>[05]<br>[05] |
| Q5 (b) | Write about equivalent diameter for annulus to be used in Reynold's number and Nusselt's number. | [05] |